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Supply and Demand for Cereals in Nepal, 2010–2030

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ABSTRACT

This paper attempts to estimate the future supply and demand for cereals in Nepal. While there has been considerable research in the past examining the agricultural sector in Nepal, to the best of our knowledge there has been no analysis of the supply-demand scenario for food grains in the country. The analysis undertaken in this paper attempts to bridge this gap in the literature by estimating supply and demand models for the three most important cereals in Nepal's food basket: rice, wheat, and maize. The supply projections have been carried out on the basis of a single-crop production function model using data for the period 1995–2008. For estimating the demand function and projecting future demand, data from the Nepal Living Standards Survey II (NLSS II), undertaken in the year 2003/04, are used.

The forecasting exercise undertaken here provides a possible picture of rice, wheat, and maize production and demand under business-as-usual, optimistic, and pessimistic scenarios for the years 2010, 2015, 2020, 2025, and 2030. These future projections show a persistent shortfall in the domestic production of rice in Nepal to meet the total demand. Under the pessimistic set of conditions the rice demand in Nepal is projected to be more than double the domestic production in the year 2030. Under the optimistic scenario, production deficit is about 41 percent. In the case of wheat and maize, however, our model estimates a persistent surplus in the domestic production over total domestic demand, going up to as high as 75 percent for wheat and 64 percent for maize under optimistic conditions for the year 2030.

Overall, the prime concern for Nepal in ensuring sufficient food supply for the future appears to be with regard to rice, as evidenced by the substantial deficit between the projected supply and demand for rice. Our estimates show that the gap between the domestic production and direct demand by households for rice is likely to vary between 19 percent and 80 percent. It appears that even with accelerated irrigation and increasing fertilizer supply, this deficit in rice would remain. However, technological inputs such as improved seeds, which are not adequately captured in our model, could help increase the yield frontier and help meet a part of this deficit in the future.

Keywords: Nepal, cereal supply, cereal demand

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1. INTRODUCTION

Nepal's economy is predominantly based in the agriculture sector, with more than 34 percent of the gross domestic product (GDP) for the triennium ending 2008/09coming from this sector (NRB 2010). Cereal crops are the mainstay of Nepal's agriculture, with the key cereal crops being rice, maize, and wheat. These three cereals occupy the major share of cropped area in Nepal, making up more than 75 percent of total cultivated area. Rice, the most common crop, accounted for 35 percent of total cultivated area and 46 percent of cereal area in 2008/09 (Nepal, MoAC 2009). Cereals in Nepal are also crucial from the food security point of view because they form the staple diet of the Nepalese population, providing nearly 69 percent of total dietary energy and 63 percent of total dietary protein during the period from 2005 to 2007 (FAO 2010a).

The low productivity and sluggish growth of these three major cereals have been major concerns (ADB, DFID, and ILO 2009; IFPRI 2010) from the economic and poverty alleviation point of view as well as that of food security in Nepal. The government of Nepal estimated a cereal deficit of 132,000 tons in 2008/09, and this deficit has been as high as 485,000 tons in poor production years in the past (Nepal, MoAC 2009).

Various attempts have been undertaken by the government as well as other development agencies in Nepal in order to address the issue of agricultural growth. The government programs and policies have largely been based on the Agriculture Perspective Plan (APP), which envisages agricultural growth through targeted investments in priority input sectors such as irrigation and fertilizers (APROSC and JMA 1995). However, government programs based on the APP as well as other policies and programs have failed to achieve the desired results. A review of agricultural performance in the five years after the implementation of the APP noted that while performance had improved relative to the past, "the impact of policy reforms and programs has been positive, but still modest and fragile" and that the APP requires "reformulation in view of the new policy and institutional environment" (ANZDEC 2002, xiii).

Numerous reports since then have looked at past trends in agricultural performance in Nepal and proposed investment strategies and policies for augmenting production (IDL Group 2006; Karkee 2008). However, to the best of our knowledge, there has not been much literature on forward-looking projections of either food supply or food demand in Nepal. The only exception is the study by Kumar, Mruthyunjaya, and Birthal (2007) that gave forecasts of the demand for important cereals for the years 2015 and 2025 in major South Asian countries, including Nepal, using the food characteristics demand system suggested by Bouis and Haddad (1992). Their study showed that under low income growth the per capita rice consumption in Nepal would vary in the range of 96.7 to 97.3 kilograms per year, while under high income growth it would vary in the range of 96.7 to 98.0 kilograms per year. Wheat consumption was projected to range from 36.0 to 37.5 kilograms per year under low income growth and from 34.2 to 37.5 kilograms per year under high income growth. No forecasts are available on the supply side, so we are not able to assess the future supply–demand scenario. A recent stocktaking study on food and nutritional security in Nepal undertaken by the International Food Policy Research Institute (IFPRI) identifies this critical gap, which needs to be bridged in order to better inform policymaking for agricultural growth and food security in Nepal (IFPRI 2010).

The analysis undertaken in this paper attempts to bridge this gap in the literature by estimating supply and demand models for the three most important cereals in Nepal's food basket: rice, wheat, and maize. The supply projections have been carried out on the basis of a single-crop production function model using data for the period 1995–2008. For estimating the demand function and projecting future demand, data from the Nepal Living Standards Survey II (NLSS II), undertaken in the year 2003/04, are used.

The paper first discusses the supply projection exercise in Section 2, followed by a description of the demand projection exercise in Section 3. Both of these sections describe the data used, their sources and limitations, and the methodology adopted to model supply or demand and to carry out future projections; examine the estimated model results; and end with a discussion of the projection of future supply or demand of rice, wheat, and maize under various scenarios. Section 4 assesses the projected gap between supply and demand for rice, wheat, and maize, and this is followed by some concluding remarks in the final section.

2. MODELING AND FORECASTING THE SUPPLY OF CEREALS IN NEPAL

Methodology and Data

Output of a crop is likely to be influenced by its price; the price of various inputs such as seed, irrigation, fertilizer, and the like, which would affect their usage; and also climatic factors such as rainfall. Ideally, the methodological framework for modeling output should be based on a profit function from which the optimal levels of output and inputs are determined given a certain technology as specified through a production function. In the absence of relevant price data, as is the case in Nepal,[1] an alternative approach is to estimate a production function assuming that the observed levels of input usage reflect optimal behavior on the part of the farmers. This study takes the latter approach.

To estimate the production functions for the three major cereals—rice, wheat, and maize—data on output, acreage, gross irrigated area, rainfall, and two inputs (fertilizers and seeds) were collected from the Ministry of Agriculture and Co-operatives (MoAC) and the Central Bureau of Statistics (CBS) of Nepal. Descriptions of each variable and the data source(s) used for setting up each one are given in Table 2.1. It should be noted that the data on the physical output of rice on the supply side is in terms of paddy production. Hence, supply modeling and projections have been carried out in terms of paddy.[2]

Table 2.1—Description of variables and data sources used

Variable	Symbol	Unit	Data source
Output	pdy, wht, mz	Physical output in tons	Nepal, MoAC 2009
Acreage	ar_pdy, ar_wht, ar_mz	Area under respective crop in hectares	Nepal, MoAC 2009
Irrigated area	irri	Total irrigated area in hectares	Nepal, MoAC 2009
Rainfall	rf	Annual average rainfall in millimeters	Nepal, CBS 2008, 2009
Fertilizer	fert	Total annual fertilizer supply in tons	Nepal, MoAC 2009
Seeds	pdy_sd, wht_sd, mz_sd	Total annual supply of improved seeds per crop in tons	Nepal, MoAC 2009

Source: Authors.

The available data suffer from several limitations, as follows: First, with regard to seeds, the data on supply of improved seeds in Nepal provided by MoAC consider only officially recognized sources of seeds. It is widely acknowledged that there is considerable import of improved seeds into Nepal across its porous border with India (and perhaps from China as well), which is not reflected in the official data used here (IFPRI 2010). There are no estimates available of this unofficial seed import and hence no estimate of the extent of measurement error in the official data used here.

Similarly, the data on fertilizer refer to total consumption of fertilizer from officially recognized sources of supply. Here too, the data do not take into account the large unofficial imports from India. It has been estimated that informal sources could have accounted for 60 percent of the total supply in 1997/98 and 80 percent in 2002/03 (UNWFP and FAO 2007). Estimates of the informal fertilizer imports are not available for all years.

[1] National-level data on farmgate prices of different crops and inputs are not available for Nepal. Data on retail prices of different crops in major markets of each district and the average retail price at the national level are available. These latter prices were not considered in the analysis, however, because movements in the retail prices are likely to be influenced by various other factors, not just the farmgate prices. An important factor in the case of Nepal is large-scale informal and unrecorded imports of grains from India, besides the usual trade and transport margins (and levies if any) between the farmgate and the retail market. Hence, the influence of price on output is not considered in the analysis, which is a major limitation.

[2] For the purpose of comparing the supply-demand gap, the supply side output has been converted to rice equivalent by multiplying output with a factor of 0.63.

Besides these limitations, in the case of irrigation and fertilizer, the available data are gross irrigated area over all crops and total fertilizer usage across all crops. Crop-specific data on irrigation and fertilizer usage are not available. Hence, in the present analysis these two variables are interpreted as indicators of overall availability of irrigation and fertilizer rather than reflecting actual intensity of use.

Finally, annual average rainfall data at the national level were also unavailable. For the purpose of estimation here, annual average rainfall from 41 stations for the period 1995 to 2008 was used to arrive at an area-weighted national average. The limited time period for which rainfall data were available meant that the estimation could be carried out based only upon observations for these years.

Bearing in mind these data limitations, we use a single-commodity production function for our estimation here. The physical output of each of the three crops in tons (Q_i) is taken to be a function of the area under crop i (A_i), quantity of improved seed supplied for crop i (S_i), gross irrigated area (I), total fertilizer supply (F), and annual average rainfall (R). The empirical model used is the Cobb–Douglas function:

$$\mathbf{Q_i = \beta_0\, A_i^{\beta_1}\, S_i^{\beta_2}\, I^{\beta_3}\, F^{\beta_4}\, R^{\beta_5}\, \varepsilon}\,, \tag{1}$$

where ε is the error term. The estimation is undertaken using the double-log form of the Cobb–Douglas function for each of the three crops using an ordinary least squares (OLS) regression with robust standard errors:

$$\mathbf{\ln(Q_i) = \ln(\beta_0) + \beta_1 \ln(A_i) + \beta_2 \ln(S_i) + \beta_3 \ln(I) + \beta_4 \ln(F) + \beta_5 \ln(R) + \ln(\varepsilon)}. \tag{2}$$

For each of the three crops, the estimated models were checked for presence of autocorrelated error terms. In cases where the Durbin–Watson d-statistic indicated autocorrelation, the regression model was estimated through a Prais–Winsten regression. For each of the three crops, only the significant variables were retained and the regression model was re-estimated.

Estimation Results

Production Function

As a preliminary step in identifying the significant variables in each of the production models, we first estimate the coefficient of correlation between the logarithms of various variables. The correlation matrix is presented in Table 2.2. We find that physical output of each of the three crops shows significant correlation with the crops' respective cropped areas and also with irrigated area. Fertilizer supply turns out to be significantly correlated with production of wheat and maize but not of paddy. One should also note that crop acreage of wheat and maize, especially the latter, are also correlated with the gross irrigated area.

Table 2.2—Correlation matrix

	ln_pdy	ln_wht	ln_mz	ln_ar_pdy	ln_ar_wht	ln_ar_mz	ln_rf	ln_irri	ln_fert	ln_pdy_sd	ln_wht_sd	ln_mz_sd
ln_pdy	1											
ln_wht	-	1										
ln_mz	-	-	1									
ln_ar_pdy	0.792***	-	-	1								
ln_ar_wht	-	0.811***	-	-	1							
ln_ar_mz	-	-	0.992***	-	-	1						
ln_rf	0.313	-0.041	-0.075	0.530*	-0.046	-0.084	1					
ln_irri	0.757***	0.926***	0.940***	0.294	0.724***	0.964***	-0.038	1				
ln_fert	-0.234	-0.536**	-0.719***	0.074	-0.790***	-0.692***	-0.205	-0.566**	1			
ln_pdy_sd	0.318	-	-	0.058	-	-	-0.007	0.606**	-0.688***	1		
ln_wht_sd	-	0.111	-	-	0.547**	-	-0.194	0.020	-0.416	-	1	
ln_mz_sd	-	-	-0.829***	-	-	-0.816***	-0.256	-0.796***	0.645**	-	-	1

Source: Authors' calculations.
Notes: *** p < 0.01, ** p < 0.05, * p < 0.1

The production functions in double-log form, given in equation (2), are first estimated for all three crops through an OLS regression with robust standard errors, and the results are presented in Table 2.3. We also estimate the Durbin–Watson d-statistic for each of these regressions to check for the presence of autocorrelation in the residuals, and these are found to be within the satisfactory range, indicating the absence of autocorrelation.

Table 2.3—Results of regression estimates for paddy, wheat, and maize production

Variable	(1) ln_pdy	(2) ln_pdy	Variable	(3) ln_wheat	(4) ln_wheat	Variable	(5) ln_mz	(6) ln_mz#
ln_ar_pdy	2.034***	2.244***	ln_ar_wht	3.494**	2.477***	ln_ar_mz	4.370***	3.906***
ln_irri	0.522***	0.442***	ln_irri	0.842**	1.020***	ln_irri	-0.280*	-
ln_rf	0.0377	-	ln_rf	0.0643	-	ln_rf	-0.00710	-
ln_fert	0.00486	-	ln_fert	0.0453*	0.0395	ln_fert	-0.00153	-
ln_pdy_sd	-0.00988	-	ln_wht_seed	-0.0867	-	ln_mz_seed	-0.00477	-
Constant	-21.21***	-22.82***	Constant	-44.73***	-33.67***	Constant	-41.37***	-38.98***
Observations	14	14	Observations	14	14	Observations	14	13
df	8	11	Df	8	10	df	8	11
R-square	0.937	0.929	R-square	0.941	0.927	R-square	0.990	0.979
D–W statistic	1.8005	1.935	D–W statistic	2.031	2.158	D–W statistic	2.076	2.076

Source: Authors' calculations.
Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, # Prais–Winsten regression estimates.

For all three cereals, rainfall and improved seed supply quantities were found to be insignificant (columns 1, 3, and 5 of Table 2.3). In the case of paddy and maize, only the acreage and gross irrigated area were found to be significant. In the case of wheat, along with these two variables, fertilizer supply quantity also shows some significance. In each of the cases the dependent variables were then regressed using only the significant variables (columns 2, 4, and 6 of Table 2.3).[3] Among the three crops, maize has the highest production elasticity with respect to its crop acreage, while wheat production is the most responsive to irrigation.

While the supply of improved seeds and that of fertilizer show only a weak relationship, if any, with production, a caveat in interpreting these results is the aforementioned fact that the data on seed supply and fertilizer supply do not reflect the unofficial and unrecorded trade in both of these inputs across the border with India. The actual on-farm levels of use of these inputs might be much higher than what is reflected in the official figures. For instance, farmer surveys on actual fertilizer usage indicated intensity of use in the range of 56–58 kilograms per hectare of arable area in 2002 (ANZDEC 2002; OPM 2003), whereas average fertilizer consumption per hectare of arable area as reflected in the official figures for the same period was much lower, at 24 kilograms (World Bank 2010).

Another result from these estimates, which does run contrary to expectation, is the lack of any significant relationship between production and rainfall levels.

Auxiliary Models

To use the production functions reported above for forecasting future output levels, we need to specify the future expected values of the explanatory variables in these functions. For this, auxiliary models are developed in which these explanatory variables are themselves related to other exogenous variables.

[3] The irrigation variable in the case of maize shows a negative sign (Table 2.3, column 5), possibly due to the very high correlation between maize acreage and gross irrigated area (see Table 2.2). For this reason, the irrigation variable was dropped for maize in the re-estimated model (Table 2.3, column 6). Nevertheless, the influence of irrigation on maize is captured through the auxiliary model developed below for maize acreage.

These auxiliary models are used first to project the future values of the explanatory variables, which are then used in the production functions to forecast future output levels.

In the production functions estimated for paddy, wheat, and maize production above, we find that the respective crop acreages turn out to be significant for all three, gross irrigated area is significant for paddy and wheat, and fertilizer supply is significant for wheat production. These explanatory variables can be classified as being policy variables that may be influenced by government policies or behavioral variables that are primarily dependent upon farmer choices and preferences based upon several considerations, including availability of other inputs.[4] For our purpose, irrigation, fertilizer supply, and seed supply are considered to be policy variables while crop acreage is considered to be a behavioral variable. Our approach to developing the auxiliary model for forecasting purposes differs for these two sets of variables. We specify time trend models for the policy variables, whereas we relate the three crop acreages (the only behavioral variables here) to the policy variables based on the observed pattern of correlations reported in Table 2.2.

For the crop acreages we once again specify a double-log form of the Cobb–Douglas function, similar to the one in equation (2). The dependent variable in this case is the log of the crop acreage. The independent variables considered are rainfall, gross irrigated area, improved seed supply for the respective crops, and fertilizer supply, all in logarithms. Here too, ideally we should include price information as a factor that influences the crop acreage decision. But absence of appropriate data on farmgate prices does not permit us to do so.

In each case we first estimate the model with all the variables and subsequently rerun the regression after dropping the variables that were not significant. The final estimates, which are corrected for autocorrelation, are reported in Table 2.4 (the full regression estimates are presented in the appendix, Tables A.1, A.2, and A.3). The estimated results show that paddy acreage is significantly affected by rainfall, irrigation, and fertilizer supply but not by the supply of improved seed. For wheat acreage, we find that irrigation and supply of improved seed are significant variables, and for maize acreage, irrigation is the only significant variable. The absence of any significant relationship between acreage and the supply of improved seeds in the case of paddy and maize, while surprising, is probably due to the extremely low levels that the official supply figures show. The reported supply of improved wheat seeds is certainly more sizable than that of the other two grains; on average wheat seeds made up more than 80 percent of the total annual improved supply of cereal seed for the period under consideration (Nepal, MoAC 2009). This might explain why seed supply seems to be significant only in the case of wheat and not so much for paddy or maize.

Table 2.4—Auxiliary models for behavioral variable: Crop acreage

Variable	(1) ln_ar_pdy#	Variable	(2) ln_ar_wht#	Variable	(3) ln_ar_mz#
ln_rf	0.122**	ln_rf	-	ln_rf	-
ln_irri	0.125**	ln_irri	0.223***	ln_irri	0.383***
ln_pdy_sd	-	ln_wht_sd	0.0575***	ln_mz_sd	-
ln_fert	0.0117**	ln_fert	-	ln_fert	-
Constant	11.47***	Constant	9.897***	Constant	8.354***
Observations	13	Observations	13	Observations	13
df	9	df	10	df	11
R-square	0.623	R-square	0.795	R-square	0.890
D–W statistic	2.234	D–W statistic	1.980	D–W statistic	2.730

Source: Authors' calculations.
Notes: *** $p < 0.01$, ** $p < 0.05$; # Prais–Winsten regression.

[4] This is borne out by the results shown in the correlation matrix (Table 2.2), where we found that the crop acreages show significant correlation with other variables.

We then estimate the time trends for the policy variables of interest: gross irrigation area, fertilizer supply, and improved wheat seed supply. For all three variables we use a log-linear time trend model for estimating the annual trend growth rates (Table 2.5). Our estimates indicate a trend growth rate of 1.4 percent per year in irrigated area in Nepal (column 1) and a healthy growth rate of 5.8 percent per year in improved wheat seed supply (column 3). In the case of fertilizer, however, we find a trend growth rate of -3.3 percent. This is an indication of the worrisome decline in fertilizer supply in Nepal over the last few years, especially with fertilizer supplies dwindling to even lower levels since 2006 (IFPRI 2010; Shrestha 2010).

Table 2.5—Policy variables: Time trends

Variable	(1) ln_irri#	(2) ln_fert#	(3) ln_wht_sd##
Time variable (year)	0.0142***	-0.332*	0.0583***
Constant	13.71***	14.32***	7.160***
Observations	13	13	11
df	11	11	9
R-square	0.636	0.288	0.551
D-W statistic	2.056	1.584	2.5295

Source: Authors' calculations.
Notes: *** p < 0.01, * p < 0.1, # Prais–Winsten regression, ## based on observations from the period 1998–2008.

Future Scenarios and Projections

We forecast the output of paddy, wheat, and maize for five points in time: 2010, 2015, 2020, 2025, and 2030. For this forecast, the policy variables are first projected for these years using the time trends reported in Table 2.5, with which the crop acreages are then projected, using the regressions in Table 2.4. Finally, with the projected values of both the crop acreages and the policy variables, outputs of the three crops are projected with the regressions in Table 2.3. Thus, the trend growth rates in the policy variables critically drive the entire forecasting exercise. By varying these growth rates, alternative scenarios that reflect policy interventions can be conceptualized and output projections can then be obtained under each of these scenarios. Three alternative scenarios are considered here, as described in the following subsections.

Business-as-Usual Scenarios

The projections are first carried out under a business-as-usual scenario, denoted as BAU-1, wherein we assume that the current trends in the policy variables—irrigation, fertilizer, and improved wheat seed supply—continue in the future. This assumption, however, means that the current declining trend in fertilizer supplies continues, resulting in almost negligible supply after the year 2020. This could happen if the government follows a completely hands-off policy and does nothing to arrest this declining trend or even if it tries and is completely unsuccessful in its attempts. Considering the fact that Nepal is entirely dependent on imports for meeting its chemical fertilizer needs, it is possible that the country may have difficulties in securing supplies for the quantity of fertilizer desired. But it may not be completely helpless, and such an extreme outcome as implied by BAU-1 does not seem entirely plausible. We therefore consider a slightly modified business-as-usual scenario, denoted as BAU-2, wherein we assume that the rate of decline in the fertilizer supply is gradually arrested and finally brought down to zero by the year 2025, and that the supply remains at this level for the period thereafter. In both BAU-1 and BAU-2, annual rainfall for forecasting is taken as the average annual rainfall for the period for which we have the data (1995–2008).

Under the BAU-1 scenario (Table 2.6) we find that if the irrigation coverage continues growing at the same rate as before, the gross irrigated area would reach nearly 1.5 million hectares by the year 2030. This translates to coverage of 84.9 percent of total irrigable area of the country, estimated at 1.766 million hectares (Nepal, DoI 2007). Improved wheat seed supply, growing at the present rate, would reach more than 8,500 tons by the year 2030. Assuming a per-hectare seed requirement of 100 kilograms, this would mean a seed replacement ratio (SRR) of 10.7 percent in 2030 based on the projected wheat area. Under the above-mentioned tapering off of fertilizer to negligible levels after 2020 (and with our assumption on rainfall) we find that the paddy acreage and output decline from 1.51 million hectares and 4.28 million tons, respectively, in 2010 to 1.43 million hectares and 4.24 million tons by 2030, driven by the decline in fertilizer supply. Wheat and maize acreage and production, however, continue to increase. Wheat area goes up to nearly 0.8 million hectares with a corresponding production of 2.03 million tons by 2030. In the case of maize, the area and production are projected to reach 0.985 million hectares and 3.03 million tons, respectively, by 2030. In both these crops, the area and production increases are driven by the increase in irrigation coverage. In addition, in the case of wheat, the area was found to have a significant relationship with the supply of improved seeds as well. This combined effect of increase in irrigation coverage and in improved seed supply compensates for the decline in fertilizer supply for wheat.

Table 2.6—Forecast values under the first business-as-usual scenario (BAU-1)

	Policy variable			Acreage (hectares)			Production (tons)		
Year	Irrigated area (hectares)	Wheat seed (tons)	Fertilizer (tons)	Paddy	Wheat	Maize	Paddy	Wheat	Maize
2010	1,131,165	2,737	7,088	1,517,355	701,081	883,891	4,283,401	1,529,804	1,985,341
2015	1,213,663	3,634	941	1,495,001	723,869	908,043	4,273,916	1,642,823	2,205,788
2020	1,302,178	4,825	125	1,472,976	747,398	932,854	4,264,452	1,764,193	2,450,714
2025	1,397,148	6,406	17	1,451,276	771,691	958,343	4,255,009	1,894,529	2,722,835
2030	1,499,045	8,506	2	1,429,895	796,775	984,528	4,245,586	2,034,495	3,025,173

Source: Authors' estimates.

In BAU-2, where we have altered fertilizer supply conditions, as per our assumptions, the decline in fertilizer supply slows down and eventually stabilizes at around 952 tons from the year 2025 onward (Table 2.7).[5] Consequently, the decline in paddy area and production seen in BAU-1 is also arrested, and both start to increase after 2015, reaching 1.54 million hectares and 4.98 million tons by 2030, representing an improvement of 7.4 percent and 17.4 percent, respectively, over the BAU-1 case. Wheat and maize acreages and maize production remain the same as under BAU-1, since fertilizer has no significant relationship with these variables as per our model estimates. Production of wheat, however, is boosted by the stabilization of the fertilizer supply, and by 2030 we find that wheat production reaches 2.59 million tons, an increase of 27 percent over BAU-1.

[5] The irrigated area and improved wheat seed supply projections stay the same as under BAU-1.

Table 2.7—Forecast values under the second business-as-usual scenario (BAU-2)

Year	Policy variable			Acreage (hectares)			Production (tons)		
	Irrigated area (hectares)	Wheat seed (tons)	Fertilizer (tons)	Paddy	Wheat	Maize	Paddy	Wheat	Maize
2010	1,131,165	2,737	7,382	1,518,077	701,081	883,891	4,287,979	1,532,261	1,985,341
2015	1,213,663	3,634	2,098	1,509,109	723,869	908,043	4,364,936	1,695,673	2,205,788
2020	1,302,178	4,825	1,129	1,511,457	747,398	932,854	4,518,476	1,924,437	2,450,714
2025	1,397,148	6,406	952	1,521,803	771,691	958,343	4,733,017	2,223,189	2,722,835
2030	1,499,045	8,506	952	1,535,283	796,775	984,528	4,980,008	2,585,668	3,025,173

Source: Authors' estimate.

These results convey the significance that fertilizer supply holds for improving cereal output in Nepal. More importantly, it appears that even stabilizing the fertilizer supply at a low level can lead to significant improvements in the overall cereal production. The level at which fertilizer supplies are stabilized in BAU-2 translates to less than 0.5 kilogram per hectare of arable land,[6] but our estimates indicate that even this can yield significant improvements in paddy and wheat production.

Optimistic and Pessimistic Future Scenarios

The business-as-usual scenarios essentially portray a situation where in government policies with regard to irrigation, fertilizer, and seeds and their efficacy remain at the current levels. But there is tremendous scope for accelerating the development of these farm input sectors in Nepal, in which assistance from international development partners and bilateral donors can play an important part.

We consider first a future scenario reflecting an accelerated growth in the supply of these inputs and project the cereal output in this scenario. Under this optimistic scenario (OS), we assume that the irrigation expansion is accelerated so as to cover 100 percent of the irrigable area by 2030. Considering that the irrigated area would reach almost 85 percent of the irrigable area even at the current pace of development, it is not overly optimistic to assume a sufficient increase in the pace of irrigation expansion so as to meet this 100 percent target by 2030. The supply of improved wheat seed is also assumed to accelerate so as to reach a seed replacement rate (SRR) of around 20 percent by 2030.[7] This would mean an increase in the annual growth rate to 10 percent from the current 5.6 percent.

With respect to fertilizer supply, we assume that Nepal is able to arrest the decline in fertilizer supply by 2015, bringing down the rate of decline to zero. Thereafter, we assume a constant annual growth in supply, with the fertilizer use intensity reaching just above 100 kilograms per hectare of arable area by 2030.[8] Considering the recent trend in fertilizer supply and keeping in mind the constraints that Nepal faces due to its complete import dependency for chemical fertilizer supply, achieving this turnaround would be a daunting task. One would expect that it would require robust investments in either developing domestic production facilities (which would still require a supply of imported raw material and fuel) or harnessing a secure source of fertilizer supply through trade agreements.

The second future scenario that we consider is one wherein there is a slowdown in the farm input supply sector. In this pessimistic scenario (PS), the growth in irrigated area is projected to decline from the current trend of 1.4 percent to 1.0 percent growth per year. Similarly, we also take a pessimistic

[6] The arable land is assumed to remain at its present level of 2.357 million hectares (FAO 2010b).

[7] The SRR is computed on the basis of a seed requirement of 100 kilograms per hectare. SRR is defined as (Quantity of improved seed in kg)/((Wheat acreage in ha)*(100 kg/ha)). Since the projected wheat area is itself influenced by the supply of improved seed, in both the scenarios the growth rates required to achieve the desired level of SRR are estimated by a process of iteration.

[8] This target of 100 kilograms per hectare is approximately three-fourths of the current average fertilizer usage level in neighboring India of 135 kilograms per hectare, based on figures from the World Bank (2010).

projection of the growth in improved wheat seed supply, which is lowered to 75 percent of the current growth rate. In this scenario, the fertilizer supply is expected to maintain its current negative trend in a similar fashion to the conditions envisaged in BAU-1.

Table 2.8 presents the policy variables situation—fertilizer use level, irrigation coverage, and wheat SRR—as projected under the business-as-usual scenarios compared with the conditions under the pessimistic and optimistic scenarios that have been described here.

Table 2.8—Comparison of fertilizer usage, irrigation development, and wheat SRR under various scenarios

Year	Fertilizer use intensity (kg per ha of arable area)				Irrigation development (% of irrigable area)			Wheat SRR (%)		
	BAU-1	BAU-2	PS	OS	BAU-1	PS	OS	BAU-1	PS	OS
2010	3.01	3.13	3.0	3.3	64.1	63.8	65.1	3.9	3.8	3.9
2015	0.40	0.89	0.4	1.8	68.7	67.0	75.0	5.0	4.6	5.7
2020	0.05	0.48	0.1	6.9	73.7	70.5	87.0	6.5	5.6	8.6
2025	0.01	0.40	0.0	26.4	79.1	74.1	100.0	8.3	6.7	13.2
2030	0.00	0.40	0.0	101.9	84.9	77.8	100.0	10.7	8.2	20.2

Source: Authors' estimates.
Notes: BAU, business-as-usual; PS, pessimistic scenario; OS, optimistic scenario.

On the basis of the projected policy variables under the optimistic and pessimistic scenarios, we first estimate the acreage of the three crops. The rainfall used is the period average (1995–2008), the same as in the BAU case. Figure 2.1 shows the comparative picture for the projected acreages of paddy, wheat, and maize under the BAU, OS, and PS conditions. The projected acreages for all the years under various scenarios are presented in the appendix (Table A.4).

The projected paddy area for 2030 shows an increase of 16.9 percent under OS as compared with the projected area in 2030 under BAU-1, and an increase of 8.9 percent as compared with the BAU-2 scenario. In PS we find that the paddy acreage is 1.1 percent lower than in the BAU-1 case and 7.9 percent lower as compared with the BAU-2 projected acreage for 2030. Wheat acreage projections for 2030 increase by 8.1 percent and maize acreage by 2030 shows an increase of 6.5 percent under the conditions in OS as compared with the BAU scenarios. Under PS the wheat acreage falls by 3.6 percent and maize by 3.3 percent as compared with BAU-1.

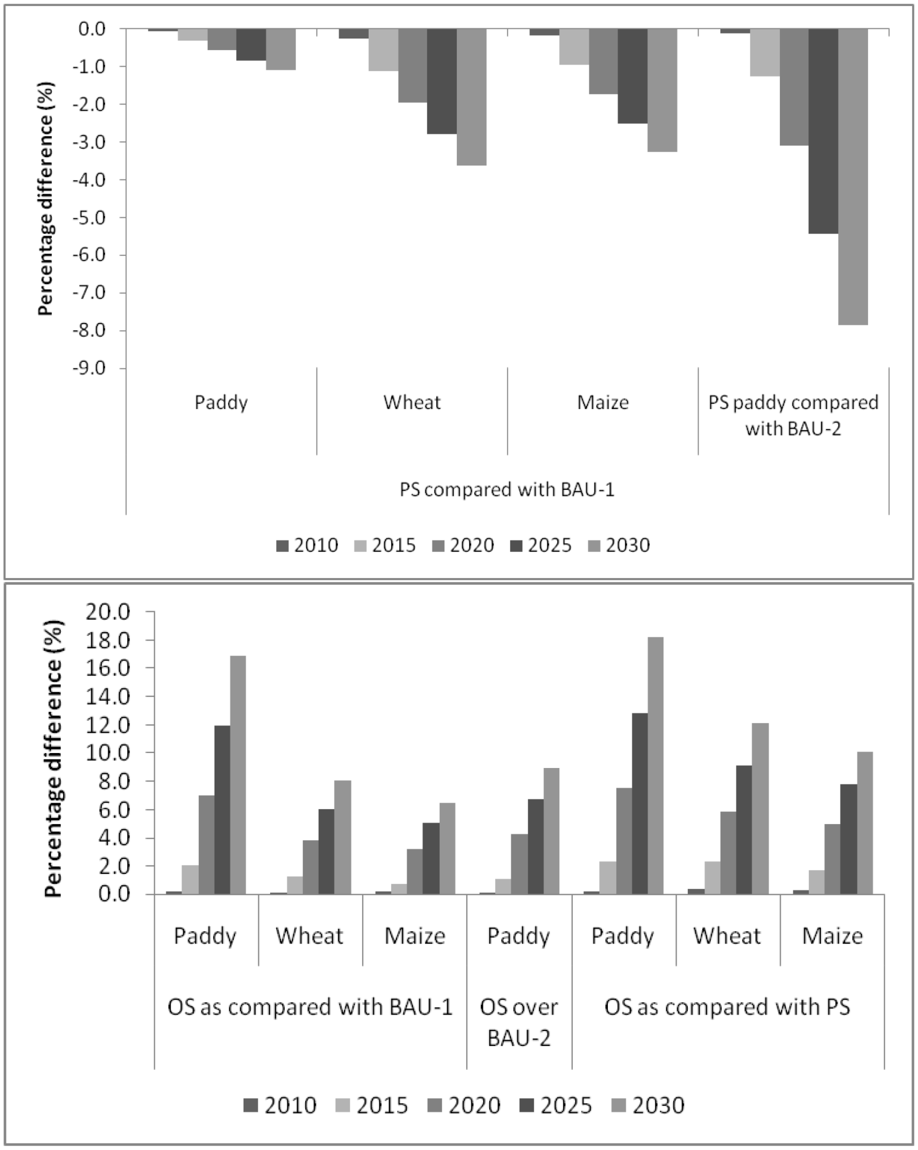
Once we have estimated the policy variables and the acreage, we then forecast the physical output for paddy, wheat, and maize under OS and PS. Figure 2.2 presents a comparison of the increase in projected production for the various years under the growth scenarios compared with the corresponding projections under the BAU scenarios. The production projections for all of these scenarios for 2010, 2015, 2020, 2025, and 2030 are presented in the appendix (Table A.5).

Under OS we find that paddy production is boosted by the increase in acreage brought about by the increase in irrigation coverage as well as that of fertilizer supply. The resulting increase in output when compared with the BAU scenarios, shows an increase of 52.7 percent and 30.2 percent over BAU-1 and BAU-2, respectively, by the year 2030. Under PS the paddy output is lower than under the BAUs, as expected, and by the year 2030, the projected output shows a reduction of 6.1 percent and 19.9 percent compared with the BAU-1 and BAU-2 projections, respectively. The projected output under OS is significantly higher than the output projected under PS, by about 63 percent.

In the case of wheat, along with the effects of irrigation and fertilizer, the increase in improved wheat seed supply also augments production under OS. As a result, we find that the projected wheat production for the year 2030 under OS shows an increase of 126 percent as compared with the BAU-1 scenario and more than 78 percent as compared with the BAU-2 scenario. Under PS, the projected wheat output by 2030 turns out to be about 17 percent and 34 percent, respectively, lower than the output projected under BAU-1 and BAU-2, and nearly 63 percent lower than the output projected under OS.

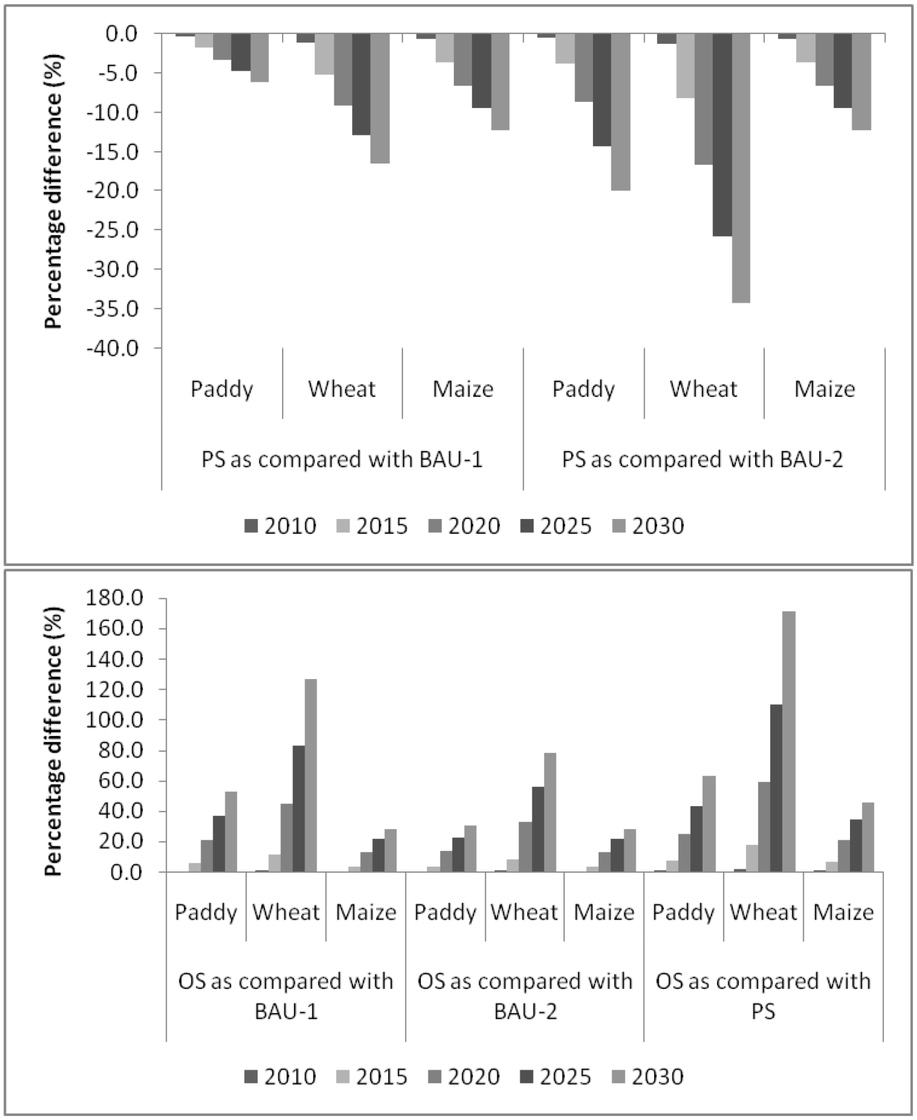
In the case of maize, with irrigation being the main driver of the increased output, we find that the projected production for the year 2030 under OS is nearly 28 percent higher than under the BAU scenarios. On the other hand, under PS the projected production for 2030 falls by more than 12 percent in comparison with the BAU scenario, a reduction of 31 percent as compared with the projected output under OS.

Figure2.1—Comparison of projected paddy, wheat, and maize acreages under various scenarios



Source: Authors' estimates.
Notes: BAU, business-as-usual; PS, pessimistic scenario; OS, optimistic scenario.

Figure 2.2—Improvement in the production of paddy, wheat, and maize under PS and OS as compared with BAU; and OS as compared with PS



Source: Authors' estimates.
Notes: BAU, business-as-usual; PS, pessimistic scenario; OS, optimistic scenario.

3. MODELING AND FORECASTING DEMAND FOR CEREALS IN NEPAL

In this section we develop a set of models that will be used for forecasting the different components of domestic demand for rice[9], wheat, and maize. We focus only on domestic demand because the objective of the paper is to assess the gap between domestic supply and domestic demand, which we assume will be met by trade (either imports or exports). In any case, in the context of Nepal, export demand for cereals is unlikely to be of concern in the foreseeable future because the country has been a net importer of cereals for most of the past three decades, and this situation is unlikely to be reversed any time soon. In the rest of this section, we first describe the models and data used and then give the estimation results and demand forecasts under different scenarios.

Methodology and Data

The total domestic demand for individual cereals such as rice, wheat, and maize consists of (a) direct demand by households and (b) indirect demand as raw materials in own and other production sectors (that is, seed and feed requirements and wastage).

Household Demand Model

Household demand for food items including the three major cereals is modeled using the almost ideal demand system (AIDS) developed by Deaton and Muellbauer (1980). The AIDS model for *n* goods is written as

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{y}{P}\right), \tag{3}$$

where w_i is the share of i^{th} good in the total expenditure; P_i is the price of the i^{th} good; y is the total expenditure on all the goods; P is a price index; and $\alpha_i, \gamma_{i,j}$ and β_i are parameters to be estimated. The price index P is the translog index, given as

$$\ln f(\mathbf{p}) = \alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j . \tag{4}$$

Since this price index is a nonlinear equation, to simplify the estimation procedure Deaton and Muellbauer (1980) suggest using a linear price index (Stone price index), given as

$$\ln P = \sum_{i=1}^{n} w_i \ln p_i . \tag{5}$$

The AIDS model (3) with the Stone price index (5) is often called the linear approximate AIDS (LA-AIDS). The parameters of the AIDS model have to satisfy the adding-up condition, the homogeneity condition, and the Slutsky symmetry restriction, which are given as

$$\sum_i \alpha_i = 1,\ \sum_i \beta_i = 0,\ \sum_i \gamma_{ij} = 0\ \ j = 1,2,\ldots,n,\ \sum_j \gamma_{ij} = 0\ \ i = 1,2,\ldots,n, \text{ and } \gamma_{ij} = \gamma_{ji}\ \ i,j = 1,2,\ldots,n . \tag{6}$$

Since the AIDS model (3) is a system of *n* equations, the estimation procedure has to take care of possible cross-equation correlations. Hence, the model is estimated by the seemingly unrelated regressions (SUR) procedure.

[9] Unlike in the previous section on supply projections, demand modeling / projections are carried out in terms of rice equivalents.

Expenditure elasticity (e_i) and price elasticities (η_{ij}) are given as $e_i = 1 + (\beta_i/w_i)$ and $\eta_{ij} = -\delta_{ij} + (\gamma_{ij}/w_i) - (\beta_i/w_i)w_j$ for all $i, j = 1, 2, \ldots, n$, where δ_{ij} is the Kronecker delta that is unity if $i = j$, and zero otherwise. In this study, the elasticities are computed at sample mean.

Food Budget Model

Since the focus of this paper is primarily on cereals, in this paper the AIDS model is estimated for 14 food commodities only, as described below. Accordingly, the total expenditure y in the AIDS equation (3) refers to that portion of a household's expenditure spent on food items only. For forecasting purposes, it is therefore essential to model the food budget itself. We specify a simple model as follows:

$$lnFB = \alpha + \beta lnINC + \mu, \tag{7}$$

where FB is food budget per capita and INC is a measure of income per capita. Prices (or an aggregate index of food prices) are not considered here because the forecasting exercise is carried out under the assumption of constant food prices. Moreover, data on appropriate prices were not available.

Estimating Seed, Feed, and Wastage

After estimating the direct demand (D) projections based on the LA-AIDS model, which is nothing but household (human) demand for cereals, it is important to look at the indirect demand, especially the seed, feed, and wastage. Considering T to be the total demand for a particular commodity, from the input–output structure of a country it is possible to derive μ, which is the fraction of the total demand for a particular commodity that goes toward the indirect demand or intermediate demand (ID) in the form of seed, feed, or waste. The total (T) and indirect demand (ID) in this case can then be determined, respectively, as

$$T = D / (1 - \mu) \tag{8}$$

and

$$ID = T \text{ x } \mu, \tag{9}$$

such that $D + ID = T$.

Data

The LA-AIDS model (3) is estimated using household data taken from the Nepal Living Standards Survey 2003/04, known as NLSS II (Nepal, CBS 2005). This survey covered a nationally representative cross-section to estimate trends and levels of socioeconomic indicators in Nepal and its different geographic regions. NLSS II covered a total sample of 3,912 households. These households were selected in two stages. First, a sample of 326 primary sampling units (PSUs) was selected from six geographical strata using a probability proportional to size (PPS) method. Within each PSU, 12 households were selected by systematic sampling from the total number of households listed.

Section 5 of the NLSS II (Nepal, CBS 2005) provides information on consumption of and expenditures on 68 food items. The survey reports monthly consumption of home-produced food items, monthly expenses on purchase, and annual value of in-kind food received with the reference period of the past 12 months. For the analysis undertaken here, the 68 food items were grouped into 14 food item groups. The 14 broad food groups are presented in the appendix (Table A.6). These broad food groups were arrived at by suitably aggregating the constituent items with appropriate scale factors. For instance, to combine fine rice, coarse rice, and flat rice into one category, the quantity of flat rice was scaled by a factor of 0.85 to convert it into rice equivalents. Similarly, to scale maize flour to maize, a factor of 0.95 was used, and to convert wheat flour to wheat equivalent terms, a factor of 0.95 was used. Table A.6 reports the scale factors used for various items.

The food budget model given in equation (7) is also estimated with the data on food budget and per capita income from the NLSS II. However, for forecasting purposes, first of all one needs to project the future values of per capita income itself. The NLSS data, being cross-sectional, do not allow us to evaluate the trend in per capita income in the country. Hence, we use an alternative measure of per capita income, namely the gross national income per capita (GNIPC) from the World Development Indicators (WDI) (World Bank 2010),[10] for which time series information is available, permitting us to work out the trend.

The food budget model and the LA-AIDS model give forecasts of the per capita food budget and per capita demand for each group of commodities, respectively. To arrive at the total demand, however, these per capita demands are combined with the projected population of Nepal based on estimates by the United Nations Population Division (UNPD 2009) to arrive at the total demand.

Estimation Results

AIDS Model

The estimates of the expenditure and price elasticities based on the LA-AIDS model are presented in Table 3.1. The estimated parameters are presented in the appendix (Table A.7). We find that the expenditure and price elasticities conform to the expected behavior of normal goods. The response of cereals to a change in income is relatively low compared with that of other food groups. Among the cereals, rice has the highest expenditure elasticity at 0.81, followed by wheat at 0.67, while maize has the lowest elasticity at 0.40. In contrast with cereals, the other food items have higher expenditure elasticities. Milk, poultry, and miscellaneous food products (consisting primarily of fruits, nuts, and processed food products including beverages) have expenditure elasticities exceeding 1. With regard to price elasticity, too, we find that the demand response of cereals to a change in prices is low in comparison with that of other food items. The relatively low expenditure and price elasticities for cereals suggest that their demand will be relatively less volatile in relation to changes in income and prices than would be the case for other food products.

[10] The World Development Indictors report GNIPC in current prices, which we convert to constant prices using a GDP deflator.

Table 3.1—Expenditure elasticities and price elasticities estimated based on LA-AIDs model

	Commodity group	Expenditure elasticity	Own- and cross-price elasticities (uncompensated)													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Rice	0.81	-0.79	-0.02	0.04	0.01	-0.05	-0.04	-0.03	0.01	-0.02	0.00	0.04	-0.01	-0.01	0.06
2	Maize	0.40	-0.02	-0.54	-0.43	0.05	0.21	0.08	0.17	-0.02	0.25	-0.16	0.06	-0.06	0.07	-0.05
3	Wheat	0.67	0.31	-0.48	-0.43	-0.10	0.08	-0.20	-0.10	0.07	-0.11	-0.04	0.13	-0.09	-0.01	0.30
4	Other cereals	0.53	0.27	0.16	-0.29	-0.77	0.48	0.44	0.17	0.14	0.31	0.06	0.10	-0.15	0.16	-1.59
5	Pulses and legumes	0.87	-0.31	0.19	0.06	0.14	-0.92	-0.01	-0.05	0.04	-0.14	-0.01	-0.02	0.02	-0.03	0.16
6	Milk	1.07	-0.20	0.01	-0.11	0.06	-0.02	-0.81	0.05	-0.05	-0.05	-0.02	0.02	-0.02	0.00	0.07
7	Cooking oils	0.85	-0.10	0.07	-0.06	0.03	-0.02	0.07	-0.91	-0.01	-0.02	0.00	0.02	0.01	0.01	0.07
8	Potatoes	0.97	0.10	-0.07	0.12	0.08	0.07	-0.19	-0.05	-0.88	0.02	0.11	0.02	0.04	0.17	-0.51
9	Vegetables	0.96	-0.17	0.20	-0.11	0.08	-0.12	-0.07	-0.04	0.01	-0.69	-0.05	-0.10	-0.01	-0.05	0.17
10	Fish	0.98	-0.06	-0.69	-0.17	0.07	-0.06	-0.19	0.01	0.23	-0.21	-1.15	-0.05	-0.06	0.27	1.07
11	Poultry	1.09	0.06	0.01	0.06	0.01	-0.02	0.02	0.00	0.00	-0.07	-0.01	-1.14	-0.01	0.01	0.00
12	Spices	0.76	-0.06	-0.09	-0.10	-0.05	0.03	-0.01	0.02	0.03	0.00	-0.01	0.00	-0.70	0.04	0.13
13	Sugar	0.97	-0.28	0.21	-0.04	0.15	-0.11	0.04	0.04	0.27	-0.17	0.22	0.08	0.11	-1.07	-0.43
14	Miscellaneous	1.86	-0.17	-0.09	0.04	-0.18	0.00	-0.03	-0.04	-0.11	0.02	0.08	-0.06	-0.01	-0.06	-1.24

Source: Authors' estimates.

Food Budget Model

The food budget model, as described in equation (7), is estimated on the basis of the estimated food expenditure and income as reported in NLSS II. The model estimates are presented in Table 3.2. For forecasting the future values of the food budget, however, we need to first predict the future values of per capita income. We use the time series data on GNIPC from the WDI (World Bank 2010) to project the future per capita income under different scenarios.

Table 3.2—Food budget model estimates

Log(food budget)	Coefficients
Intercept	1.170451***
Log(income per capita)	0.663443***
Adjusted R-square	0.986798

Source: Authors' estimates.
Note: *** $p < 0.01$.

Model Validation

Before proceeding with the forecasting exercise, we first validate the LA-AIDS and food budget models that will be used for carrying out projections. Validation is carried out for two time points for which data on household demand are available, namely the two NLSS rounds, corresponding to 1995/96 (NLSS I)[11] and 2003/04 (NLSS II). Given the difference of about eight years between the two rounds of NLSS surveys, this is really an assessment of the medium-term forecasting performance of the LA-AIDS and food budget models. Validation over a longer time horizon is not possible for want of data on demand for each group of commodities. Table 3.3 presents the results of our validation exercise.

For the time point 2003/04, we present three sets of forecasts to evaluate the model performance. First (Set 1), we forecast the demand for each group of commodities using the actual observed values for the food budget and prices from NLSS II (Table 3.3, columns 2 and 3). This helps us evaluate the performance of the LA-AIDS model. The forecast errors for cereals, potatoes, and sugar are quite acceptable (less than 10 percent). It may be noted that all these are either single commodities (such as wheat and potatoes) or do not involve aggregating diverse constituent commodities (see Table A.6 in the appendix). In contrast, fairly large forecast errors are seen in the case of the remaining commodities, all of which involve aggregation over diverse constituent commodities. From the perspective of this paper, which focuses on the three main cereals (rice, wheat, and maize), the low forecast errors are a matter of comfort.

[11] Because the detailed data of NLSS I were not readily accessible, we rely on Nepal, CBS (2006), which provides limited information on different variables from the NLSS I survey. The information on household demand in this source pertains to the three major cereals and a few other commodities. Among these, only cereals, potatoes, and fish directly correspond to the commodities covered in this paper. Hence, the validation exercise for 1995/96 is carried out only for these commodities.

Table 3.3—Model validation for 2003/04 and 1995/96

Item	2003/04							1995/96		
	NLSS II actuals*	Set 1 estimates	Prediction error (%)	Set 2 estimates	Prediction error (%)	Set 3 estimates	Prediction error (%)	NLSS I actuals**	Projected values	Prediction error (%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Food budget (NPR)	8,035	8,035	0.0	8,793	9.4	9,844	22.5	n.a.	5,605	n.a.
Rice	103.1	99.5	-3.5	97.7	-5.3	104.3	1.2	97.1	91.8	-5.5
Maize	25.4	26.5	4.6	25.6	0.9	26.7	5.3	33.9	37.1	9.4
Wheat	20.6	20.1	-2.6	19.1	-7.2	19.6	-4.8	26.8	25.1	-6.4
Other cereals	10.9	11.6	6.5	11.4	4.0	12.1	10.6	n.a.	8.8	n.a.
Pulses and legumes	6.6	3.5	-47.8	3.4	-48.5	3.7	-44.6	n.a.	2.5	n.a.
Milk	31.1	22.4	-28.2	22.5	-27.8	24.8	-20.3	n.a.	15.2	n.a.
Cooking oils	4.7	3.2	-32.3	3.1	-33.2	3.4	-28.1	n.a.	2.3	n.a.
Potatoes	17.9	17.6	-1.4	17.6	-1.7	19.2	7.2	13.2	12.4	-5.5
Vegetables	10.6	4.9	-53.5	4.9	-53.7	5.3	-49.5	n.a.	3.5	n.a.
Fish	1.1	0.6	-46.2	0.6	-46.3	0.6	-41.4	0.7	0.4	-46.0
Poultry	23.3	8.2	-64.7	8.3	-64.4	9.2	-60.6	n.a.	5.5	n.a.
Spices	5.0	3.7	-26.2	3.6	-27.8	3.9	-23.1	n.a.	2.8	n.a.
Sugar	4.4	3.9	-10.4	3.9	-10.7	4.3	-2.6	n.a.	2.8	n.a.

Sources: * Nepal, CBS 2005; ** Nepal, CBS 2006; all else authors' calculations.
Notes: Validation is not done for the commodity group Misc. as it is an aggregate commodity over diverse items. For a description of the Set 1, Set 2, and Set 3 estimates for 2003/04, see main text; NPR, Nepalese rupees.

In the second set of forecasts for 2003/04 (Set 2, Table 3.3, columns 4 and 5), we first obtain the forecast of the food budget using the actual observed per capita income as reported in NLSS II and use this predicted value of the food budget in the LA-AIDS model to obtain the per capita demand for each group of commodities. This helps us assess the performance of the food budget model. The estimated food budget in this case is 9.4 percent higher than the NLSS II observed level.

In the final set of forecasts for 2003/04 (Set 3, Table 3.3, columns 6 and 7), we use the data on GNIPC from WDI to forecast the food budget and then the demand for each group of commodities. This helps us to assess the extent to which the forecasts are affected by the difference between the estimates of the per capita income given by NLSS II (Nepal, CBS 2005) and by WDI (World Bank 2010). NLSS II estimated the 2003/04 per capita income as 15,162 Nepalese rupees (NPR), while WDI gives it as NPR 17,975. The estimated food budget using the WDI data turns out to be 22.5 percent higher than the NLSS II observed value and about 13 percentage points higher than the previous estimate, which can be attributed solely to the difference in the two datasets. This should be borne in mind while examining our forecasts for the future, which are based on GNIPC trends in the WDI data.

After assessing the performance of the models for 2003/04, we next assess the models' prediction performance for 1995/96. We use the actual value of GNIPC to estimate the food budget and use this in the LA-AIDS model to predict the per capita demand for each group of commodities in 1995/96. These predicted values are then compared with the actual observed levels reported by NLSS I (Table 3.3, columns 8, 9, and 10). These show that the error in the model performance over the medium term is less than 10 percent for the three major cereals, and also for potatoes.

Future Scenarios and Projections

The future demand forecasts are based on the conditions envisaged under various possible scenarios. These scenarios in turn are based on the projected growth in GNIPC at constant prices, taken from the WDI (World Bank 2010). We first envisage a business-as-usual scenario (BAU) wherein the current trend in GNIPC growth at 2.1 percent per capita is expected to continue, and we project the estimated demand for the years 2010, 2015, 2020, 2025, and 2030. We then also construct two alternative scenarios, a pessimistic scenario (PS) in which the GNIPC growth is expected to decline to 1.6 percent and an optimistic scenario (OS) in which the GNIPC growth is projected to increase to 2.6 percent per year. We use the projected income levels under these alternative scenarios to arrive at the corresponding food budgets. These are presented in Table 3.4, along with the projected population, taken from UNPD (2009).

Table 3.4—Projected population and food budget per capita

Year	Population (thousands)	Estimated food budget per capita (NPR)		
		BAU	PS	OS
2010	29,853	10,877	10,824	10,930
2015	32,503	11,653	11,315	12,000
2020	35,269	12,485	11,829	13,174
2025	38,031	13,376	12,365	14,463
2030	40,646	14,331	12,927	15,879

Sources: Population figures are from UNPD (2009); food budgets are authors' estimates.
Notes: NPR, Nepalese rupees; BAU, business-as-usual; PS, pessimistic scenario; OS, optimistic scenario.

Once the food budget under each of these scenarios has been projected, the per capita demand for individual commodities is then estimated based on LA-AIDS estimates, assuming the prices remain constant at 2003/04 levels (Table 3.5). Under the three growth scenarios, per capita projections of the demand for rice, wheat, and maize in 2030 are in the ranges of 111.16–119.46, 21.98-22.01, and 29.51–30.55 kilograms per year, respectively. Although these forecasts show an increasing trend, over 26 years (2004 to 2030) the rise per year in per capita demand is quite modest. For example, in the case of rice in scenario OS, this works out to about 630 grams per capita per year, and it is far less in the case of wheat (100 grams) and maize (200 grams).

Combining these per capita demands with the population projections, the national direct demand is arrived at (Table 3.5). A large rise in the direct demand for all three cereals is observed in all three scenarios, even though the per capita demand grows only modestly. This is due to the large growth in population forecast for 2030 by the United Nations. The population in 2030 is expected to reach 40.6 million, which is nearly 1.5 times that in 2003/04 (27.2 million).

Table 3.5—Projected per capita and total human demand for rice, wheat, and maize

Crop	Year	Per capita (kilograms)			Total human demand (thousands of tons)		
		BAU	PS	OS	BAU	PS	OS
Rice	2010	108.60	108.67	108.52	3,241.90	3,244.23	3,239.59
	2015	110.71	110.83	110.58	3,598.35	3,602.31	3,594.34
	2020	112.85	111.56	114.13	3,979.97	3,934.68	4,025.29
	2025	113.47	110.80	116.19	4,315.51	4,213.66	4,418.68
	2030	115.26	111.16	119.46	4,684.98	4,518.35	4,855.67
Wheat	2010	19.61	19.66	19.57	585.56	586.76	584.36
	2015	20.73	20.93	20.53	673.78	680.25	667.29
	2020	21.20	21.30	21.08	747.65	751.35	743.54
	2025	21.63	21.66	21.57	822.56	823.65	820.32
	2030	22.01	21.99	21.98	894.71	893.69	893.30
Maize	2010	27.21	27.25	27.17	812.32	813.50	811.15
	2015	28.22	28.38	28.06	917.31	922.54	912.06
	2020	28.64	28.57	28.71	1,010.17	1,007.47	1,012.58
	2025	29.02	28.72	29.31	1,103.75	1,092.14	1,114.69
	2030	30.04	29.51	30.55	1,221.07	1,199.34	1,241.59

Source: Authors' estimates.
Note: BAU, business as usual; PS, pessimistic scenario; OS, optimistic scenario.

For estimating the total demand, we need to account for seed, feed, and wastage. In the case of Nepal, this is made difficult due to the absence of any data on input–output structure. As the next best solution for estimating this intermediate demand, we use the input–output coefficients of rice, wheat, and maize based on data for India. We make an assumption that the input–output structure in Nepal for 2003/04 was roughly similar to what prevailed in India when the latter was at a similar level of development, measured in terms of GDP per capita. The per capita GDP in Nepal in the year 2003/04 was US$230 (constant prices), which is nearly equal to the per capita GDP in India for the year 1980. Because 1983/84 is the closest year for which the input–output coefficients are available for India, we use these coefficients to estimate the intermediate demand for rice, wheat, and maize in Nepal. The values of these coefficients, denoted μ in equations (8) and (9) above, for rice, wheat, and maize are 0.1576, 0.2278, and 0.1087, respectively. The forecast estimates for the national-level indirect demand and the total demand for rice, wheat, and maize are reported in Table 3.6.

Table 3.6—Projected national-level direct, indirect, and total demand, in thousands of tons

Crop	Year	Direct demand			Indirect demand			Total demand		
		BAU	PS	OS	BAU	PS	OS	BAU	PS	OS
Rice	2010	3,241.90	3,244.23	3,239.59	606.44	606.88	606.01	3,848.35	3,851.11	3,845.60
	2015	3,598.35	3,602.31	3,594.34	673.12	673.86	672.37	4,271.47	4,276.17	4,266.72
	2020	3,979.97	3,934.68	4,025.29	744.51	736.04	752.99	4,724.48	4,670.72	4,778.28
	2025	4,315.51	4,213.66	4,418.68	807.28	788.22	826.58	5,122.79	5,001.88	5,245.25
	2030	4,684.98	4,518.35	4,855.67	876.39	845.22	908.32	5,561.38	5,363.57	5,763.99
Wheat	2010	585.56	586.76	584.36	172.78	173.13	172.42	758.34	759.89	756.78
	2015	673.78	680.25	667.29	198.81	200.72	196.89	872.59	880.97	864.18
	2020	747.65	751.35	743.54	220.60	221.69	219.39	968.26	973.05	962.93
	2025	822.56	823.65	820.32	242.71	243.03	242.04	1,065.27	1,066.67	1,062.36
	2030	894.71	893.69	893.30	263.99	263.69	263.58	1,158.70	1,157.38	1,156.88
Maize	2010	812.32	813.5	811.15	99.04	99.19	98.90	911.37	912.69	910.05
	2015	917.31	922.54	912.06	111.85	112.48	111.21	1,029.16	1,035.03	1,023.27
	2020	1,010.17	1,007.47	1,012.58	123.17	122.84	123.46	1,133.34	1,130.31	1,136.04
	2025	1,103.75	1,092.14	1,114.69	134.58	133.16	135.91	1,238.32	1,225.30	1,250.61
	2030	1,221.07	1,199.34	1,241.59	148.88	146.23	151.38	1,369.95	1,345.57	1,392.98

Source: Authors' estimates.
Note: BAU, business-as-usual; PS, pessimistic scenario; OS, optimistic scenario.

4. ASSESSING THE CEREAL SUPPLY DEFICIT OR SURPLUS

Comparison of the projected demand for rice, wheat, and maize for 2010, 2015, 2020, 2025, and 2030 with their corresponding forecast supply (domestic production) provides us with an estimate of the possible future surplus or deficit of these commodities. Table 4.1 presents the range of total demand and total supply from domestic production for these crops, and the deficit or surplus as a percentage of the domestic production. Because the supply projections for rice carried out in Section 2 above were in terms of paddy, we have converted the supply projections into rice equivalents using a factor of 0.63. Thus, the assessment of supply–demand gap is in terms of rice equivalent only.

Table 4.1—Range of projected demand, supply, and deficit or surplus

Crop	Year	Supply (thousands of tons)		Total demand (thousands of tons)		Deficit (-) / surplus (+) (%)**		Direct demand (thousands of tons)		Deficit (-) / surplus (+) (%)**	
		PS	OS	PS	OS	PS	OS	PS	OS	PS	OS
Rice*	2010	2,691	2,712	3,851	3,846	-43.1	-41.8	3,244	3,240	-20.6	-19.5
	2015	2,645	2,838	4,276	4,267	-61.7	-50.4	3,602	3,594	-36.2	-26.7
	2020	2,600	3,238	4,671	4,778	-79.7	-47.6	3,935	4,025	-51.3	-24.3
	2025	2,556	3,653	5,002	5,245	-95.7	-43.6	4,214	4,419	-64.9	-20.9
	2030	2,512	4,085	5,364	5,764	-113.5	-41.1	4,518	4,856	-79.9	-18.9
Wheat	2010	1,514	1,545	760	757	49.8	51.0	618	615	59.2	60.2
	2015	1,558	1,829	881	864	43.5	52.7	716	702	54.1	61.6
	2020	1,604	2,547	973	963	39.3	62.2	791	783	50.7	69.3
	2025	1,651	3,460	1,067	1,062	35.4	69.3	867	863	47.5	75.0
	2030	1,700	4,609	1,157	1,157	31.9	74.9	941	940	44.7	79.6
Maize	2010	1,973	1,997	913	910	53.7	54.4	814	811	58.8	59.4
	2015	2,126	2,267	1,035	1,023	51.3	54.9	923	912	56.6	59.8
	2020	2,290	2,769	1,130	1,136	50.6	59.0	1,007	1,013	56.0	63.4
	2025	2,467	3,302	1,225	1,251	50.3	62.1	1,092	1,115	55.7	66.2
	2030	2,657	3,866	1,346	1,393	49.4	64.0	1,199	1,242	54.9	67.9

Source: Authors' estimates.
Notes: * Supply of rice has been converted to rice equivalent terms using a factor of 0.63; ** deficit or surplus as a percentage of supply (domestic production); PS, pessimistic scenario; OS, optimistic scenario.

Our future projections show a persistent shortfall in the domestic production of rice in Nepal to meet the total demand. Under the pessimistic set of conditions the rice demand in Nepal is projected to be more than double the domestic production in the year 2030. Under the optimistic scenario, production deficit is about 41 percent. In the case of wheat and maize, however, our model estimates a persistent surplus in the domestic production over total domestic demand, going up to as high as 75 percent for wheat and 64 percent for maize under optimistic conditions for the year 2030.

A caveat to be borne in mind with regard to these estimates is the approximations undertaken while estimating the intermediate demand due to lack of sufficient data for Nepal. It is quite possible that our estimates of the indirect demand suffer from biases of an unknown nature because we have used coefficients taken from the Indian input–output table. As a result of this uncertainty in the indirect demand our estimates of the supply–demand gap may be exaggerated. Only better data generated from within Nepal can resolve this uncertainty about the indirect demand and hence the total demand for these commodities.

The supply projections, however, have no such obvious uncertainties. Similarly, our estimates of the direct demand do not suffer from uncertainties, since the food budget and LA-AIDS models were validated and their forecast performance was found to be reasonable. Hence, we have also reported the gap between the domestic supply and the direct demand in Table 4.1. It is seen that the domestic production of rice is consistently insufficient to meet the direct demand by households. Under pessimistic conditions this deficit is about 80 percent while under optimistic conditions it is still about 19 percent.

Given that rice is the major crop under cultivation as well as the predominant staple in the Nepalese diet, this forecast deficit is a matter of concern. As seen earlier, our estimates show that the large growth in the direct demand for rice is driven mainly by the high growth in population between now and 2030 and not so much by a rise in per capita consumption. A supply-side reason behind the projected deficit under the pessimistic scenario is the projected fall in rice production due to constraints on fertilizer supply. This is no doubt a matter of concern that policymakers in Nepal should take seriously. Concerted action to overcome the fertilizer supply constraints would actually help augment rice production as shown by our forecasts under the optimistic scenario.

5. CONCLUSIONS

The forecasting exercise undertaken here provides a possible picture of rice, wheat, and maize production and demand under business-as-usual, optimistic, and pessimistic scenarios for the years 2010, 2015, 2020, 2025, and 2030.

Our forecasts under the different scenarios suggest that in 2030 domestic production of rice is likely to vary between 2,512,000 and 4,085,000 tons, wheat between 1,700,000 and 4,609,000 tons, and maize between 2,657,000 and 3,866,000 tons. Under the pessimistic scenario, rice production in 2030 is projected to decline from even the current levels due to the continuation of the current decline in fertilizer supply to almost negligible levels. It appears that arresting the current decline and stabilizing fertilizer supplies even at a low level can result in appreciable gains in production of rice and wheat as long as irrigation growth continues to remain at current trends. Boosting fertilizer supplies does hold potential to translate into much higher rice and wheat output, as seen in the optimistic growth scenario. However, the fertilizer sector is one area where Nepal's policy options for boosting the supplies are very limited due to its complete dependence on world markets for securing supplies.

In the case of maize, we find that irrigation seems to be the only major driver, and maize acreage and production will rise as long as irrigation coverage continues to expand. Our analysis does not show any significant relationship between supply of improved maize seed and maize output. This we believe is due to deficiencies in the official data on seed supply, which do not capture the (possibly) significant quantity of unofficial seed supplies from across the border. As a result, it is not possible for us to estimate the yield advantage that an increase in improved seeds might provide. This could be an important factor, especially for maize, where the spread of hybrid maize seed in India in recent years could very well have had some influence on maize yields in Nepal too. The influence of improved seeds is captured only in the case of wheat, where each additional ton of improved seed leads to an addition of 5.75 hectares of wheat area, thereby adding to the production.

Irrigation availability comes out as an important driver of production for all three cereals. Even though the irrigation growth under the business-as-usual scenario seems to be fairly appreciable, considering the fact that Nepal is rich in water resources, accelerating irrigation development could be an effective option for the government to give an impetus to cereal production growth.

The demand for cereals in Nepal shows no sign of tapering off. With growth in income coupled with an anticipated large rise in population, the projected direct demand by households for rice, wheat, and maize shows an increasing trend, though on a per capita basis the growth in demand is quite modest. Our forecasts of the direct demand by households in 2030 for rice range between 4,518,000 and 4,856,000 tons. In the case of maize, they vary between 1,199,000 and 1,242,000 tons, while wheat is likely to be about 940,000 tons. Estimates of the indirect demand for the cereals (seed, feed, and wastage), however, suffer from uncertainties due to the lack of appropriate data for Nepal.

Overall, the prime concern for the future in ensuring sufficient future food supply appears to be with regard to rice, as evidenced by the substantial deficit between the projected supply and demand for rice. Our estimates show that the gap between the domestic production of and direct demand by households for rice is likely to vary between 19 percent and 80 percent. It appears that even with accelerated irrigation and increasing fertilizer supply, this deficit in rice would remain. However, technological inputs such as improved seeds, which are not adequately captured in our model, could help increase the yield frontier and help meet this deficit in the future. In contrast with rice, there is likely to be a surplus production of wheat and maize.

The analysis undertaken here suffers from various limitations posed with regard to data availability on both the supply and demand sides, especially indirect demand for seed, feed, and wastage. Nevertheless, the results of this exercise, we hope, will provide a useful guidepost for future analysis as well as policymaking.

APPENDIX: SUPPLEMENTARY TABLES

Table A.1—Results of regression estimates for rice area

Variable	(1) ln_ar_rice	(2) ln_ar_rice#
ln_rf	0.138*	0.122**
ln_irri	0.129***	0.125**
ln_rice_seed	0.00511	
ln_fert	0.0145**	0.0117**
Constant	11.24***	11.47***
Observations	14	13
R-square	0.603	0.623
Durbin–Watson d-statistic	2.402	2.234

Source: Authors' estimates.
Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, # Prais–Winsten regression.

Table A.2—Results of regression estimates for wheat area

Variable	(1) ln_ar_wht	(2) ln_ar_wht#
ln_rf	-0.00468	
ln_irri	0.157***	0.168***
ln_wheat_seed	0.0450**	0.0452**
ln_fert	-0.00996	-0.00946*
Constant	11.06***	10.86***
Observations	14	13
R-square	0.861	0.879
Durbin–Watson d-statistic	2.092	1.988

Source: Authors' estimates.
Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, # Prais–Winsten regression.

Table A.3—Results of regression estimates for maize area

Variable	(1) ln_ar_mz	(2) ln_ar_mz#
ln_rf	-0.0411**	-0.0171
ln_irri	0.245***	0.382***
ln_maize_seed	-0.00218	
ln_fert	-0.00765***	
Constant	10.66***	8.354***
Observations	14	13
R-square	0.975	0.897
Durbin–Watson d-statistic	1.799	2.683

Source: Authors' estimates.
Notes: *** $p < 0.01$, ** $p < 0.05$, # Prais–Winsten regression.

Table A.4—Projected area in hectares of rice, wheat, and maize under BAU-1, BAU-2, PS, and OS

Year	BAU-1			BAU-2	PS			OS		
	Rice	Wheat	Maize	Rice	Rice	Wheat	Maize	Rice	Wheat	Maize
2010	1,517,355	701,081	883,891	1,518,077	1,516,570	699,320	882,495	1,519,499	701,942	885,185
2015	1,495,001	723,869	908,043	1,509,109	1,490,369	715,875	899,469	1,524,887	732,542	914,463
2020	1,472,976	747,398	932,854	1,511,457	1,464,619	732,821	916,770	1,575,341	775,634	962,440
2025	1,451,276	771,691	958,343	1,521,803	1,439,315	750,170	934,404	1,624,257	818,382	1,006,843
2030	1,429,895	796,775	984,528	1,535,283	1,414,448	767,928	952,377	1,672,088	861,097	1,048,297

Source: Authors' estimates.

Table A.5—Projected production in tons of rice, wheat, and maize under BAU-1, BAU-2, PS, and OS

Year	BAU-1			BAU-2			PS			OS		
	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize
2010	4,283,401	1,529,804	1,985,341	4,287,979	1,532,261	1,985,341	4,270,641	1,513,913	1,973,118	4,304,242	1,545,305	1,996,712
2015	4,273,916	1,642,823	2,205,788	4,364,936	1,695,673	2,205,788	4,198,090	1,558,367	2,125,552	4,504,439	1,828,768	2,267,336
2020	4,264,452	1,764,193	2,450,714	4,518,476	1,924,437	2,450,714	4,126,772	1,604,127	2,289,763	5,140,021	2,546,671	2,768,587
2025	4,255,009	1,894,529	2,722,835	4,733,017	2,223,189	2,722,835	4,056,666	1,651,231	2,466,660	5,798,917	3,459,648	3,301,948
2030	4,245,586	2,034,495	3,025,173	4,980,008	2,585,668	3,025,173	3,987,750	1,699,718	2,657,223	6,483,811	4,609,006	3,865,561

Source: Authors' estimates.

Table A.6—Food item categories

	Food category	Unit	Constituent food items
1	Rice	Kg	Fine rice, coarse rice, beaten flattened rice (0.85)
2	Maize	Kg	Maize, maize flour (0.95)
3	Wheat	Kg	Wheat flour (0.95)
4	Other cereals	Kg	Millet, other grains/cereals (buckwheat, barley, sorghum, and so forth)
5	Pulses and legumes	Kg	Black gram (*mas*), lentil (*musuro*), red gram (*rahar*), horse gram (*chana*), other pulses (green gram, *masyang*, coarse gram, grass pea and so on), other beans (soybean, pea, bean, and so on)
6	Milk	Kg*	Milk, condensed milk (2), baby milk/powdered milk (100/13), curd/whey, other milk products (cheese, *paneer*, and so on)
7	Cooking oils	Kg	Ghee, vegetable oil, mustard oil, other oil (soybean, sunflower, corn, and so on)
8	Potatoes	Kg	Potatoes/*colocasia*
9	Vegetables	Kg	Onions, cauliflower/cabbage, tomatoes, green leafy vegetables, other vegetables (eggplant, pointed gourd, bitter gourd, and so forth)
10	Fish	Kg	Fish
11	Poultry	kg	Eggs, mutton, buffalo meat, chicken, other meats (pig, boar, duck, and so forth)
12	Spices	Kg	Salt, cumin seed/black pepper, turmeric, ginger/garlic, chilies, other spices and condiments (coriander, nutmeg, clove, and so forth)
13	Sugar	Kg	Sugar and *gur* (*sakha*r)
14	Miscellaneous	--	Fruits and nuts, non-alcoholic and alcoholic beverages, tobacco and tobacco products, miscellaneous food products

Source: Authors.
Notes: Figures in parentheses are the scale factors used for unit conversion;
* unit for milk was liters and for convenience has been converted into kilograms, with scale factor of 0.91.

Table A.7—Estimated LA-AIDS parameters

	Rice	Maize	Wheat	Other cereals	Pulses and legumes	Milk	Cooking oils	Potatoes	Vegetables	Fish	Poultry	Spices	Sugar	Miscellaneous.
Alpha	0.6769***	0.2079***	0.1794***	-0.0251*	0.1185***	0.0695	0.1642***	-0.0116	0.1058***	0.0514***	0.0625***	0.1003***	-0.0008	-0.6990***
Beta	-0.0535***	-0.0299***	-0.0153***	-0.0071***	-0.0061***	0.0073*	-0.0130***	-0.0007	-0.0021.	-0.0002	0.0073***	-0.0108***	-0.0005	0.1245***
Gamma	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0.0447***													
2	-0.0096.	0.0213***												
3	0.0099**	-0.0227***	0.0255***											
4	0.0020	0.0020	-0.0047**	0.0033.										
5	-0.0166***	0.0088***	0.0027.	0.0069***	0.0036**									
6	-0.0171***	0.0010	-0.0105***	0.0059***	-0.0011	0.0192***								
7	-0.0125***	0.0057**	-0.0058***	0.0020.	-0.0027**	0.0050**	0.0069***							
8	0.0023	-0.0017	0.0028.	0.0020*	0.0016*	-0.0047***	-0.0012	0.0029.						
9	-0.0100***	0.0107***	-0.0060***	0.0042***	-0.0068***	-0.0042***	-0.0026***	0.0004	0.0164***					
10	-0.0008	-0.0083***	-0.0020	0.0008	-0.0007	-0.0023***	0.0001	0.0027**	-0.0025***	-0.0018				
11	0.0070**	0.0008	0.0047***	0.0009	-0.0014.	0.0020	0.0003	0.0005	-0.0054***	-0.0006	-0.0104***			
12	-0.0056***	-0.0044***	-0.0050***	-0.0026***	0.0008	-0.0014	0.0001	0.0010	-0.0006	-0.0007	-0.0006	0.0129***		
13	-0.0043***	0.0032***	-0.0007	0.0022***	-0.0016***	0.0006	0.0006	0.0041***	-0.0025***	0.0033***	0.0012**	0.0017***	-0.0011	
14	0.0106.	-0.0068	0.0117**	-0.0249***	0.0066**	0.0075*	0.0041.	-0.0126***	0.0090***	0.0128***	0.0009	0.0044*	-0.0066***	-0.0167*

Source: Authors' estimates.
Notes: *** significance at 0.001, ** significance at 0.01, * significance at 0.05.

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